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Composition and Digestibility of the Ether Extract of Hays and Fodders

By G. S. FRAPS and J. B. RATHER

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Composition and Digestibility of the Ether Extract of Hays and Fodders

By G. S. FRAPS, Chemist.

J. B. RATHER, Assistant Chemist.

A few examinations by others have indicated that the ether extract of hays and fodders may contain quantities of substances other than fat. So far as we know, no digestion experiments on the constituents of the ether extract have been made. The digestibility of the usual feed stuff groups of the feed referred to in this Bulletin, methods of carrying out the digestion experiment, etc., are given in Bulletin 147.

HISTORICAL.

Koenig & Kiesow (Landw. Versuchs Stat, 16, 1873; ibid, 17, 1874) claim to have found a hydrocarbon and waxes in hay and oat straw. Rodzeszewski (Jahrbuch Agr. Chem., 1868, 205) prepared a wax-like substance from the straw of grains, melting point 42°, sublimed at 300°, soluble in ether, alcohol and carbon bisulphide.

Stellwaag (Landw. Versuchs Stat, 37, 148) determined the unsaponifiable material and constituents of ether extract of a number of concentrated feeds, and of one sample of hay. The latter contained 30.8 per cent unsaponifiable. The unsaponifiable was extracted by shaking out the soap solution with ether. We have found that this method is not applicable to hays and fodders, as the unsaponifiable matter is difficultly soluble in cold ether. Some of Stellwaag's results are given in table 1.

Von Knieriem (Landw. Jahrbuch, 29, 1900), found the ether extract of rye straw to contain 10.2 per cent unsaponifiable, of oat straw 8.6 per cent. The method of estimation was not given.

Ruempler (Chemisches Centralblatt 1903, I, 1016), claims that sugar beets contain a wax $C_{26}H_{44}O$. Another worker (Chemisches Centralblatt, 1901, II, 395) found ether extract of tobacco to contain the hydrocarbon hentricontan $C_{31}H_{64}$ and heptakosan $C_{27}H_{56}$.

Kochs and Romm (Experiment Station Record 4, 599), state that chlorophyll and wax-like substances are entirely undigested by cows.

PRELIMINARY WORK.

Preliminary work showed that the ordinary method of shaking out the soap solution in a separatory funnel with ether was not sufficient to remove the unsaponifiable matter, as the unsaponifiable is not easily soluble in cold ether.

Kutscher and Steudels apparatus for continuous percolation (Eimer and Amend catalog No. 3187) was first used to extract the unsaponifia-

ble from the soap. This method apparently worked well with the first substance (cowpea hay), although very slow. With sorghum hay, after 13 days of 7 hours each, extraction of the unsaponifiable from the ether extract of 100 grams hay, 0.11 gm. had been removed. The residue was acidified and extracted with ether. The supposed fatty acids so secured had a saponification value of 72.6. On account of the low saponification number they were again saponified and the soap extracted with hot petroleum ether, when 0.31 gm. unsaponifiable was secured. The method of extracting the soap in a percolation apparatus was, therefore, abandoned. The difficulty is due to the fact that the unsaponifiable material is not easily soluble in cold ether. The formation of an emulsion above the aqueous layer, which sometimes passed over with the ether, was another difficulty with this method.

In another experiment, purified sand was used to distribute the material and give better access to the solvent, and the dried soap extracted, but the use of sand was considered unnecessary. Extraction with petroleum ether alone does not remove all the unsaponifiable. After extraction with this solvent to completeness, ethyl ether removed additional quantities of material. The ethyl ether extract was always washed with water to remove the soap. After various other preliminary tests, the method described below was selected. The object of this method is not only to determine the quantity of the constituents, but also to secure enough for examination. We call this method the large scale method, or the "large method," to distinguish it from methods subsequently used on much smaller quantities of material.

TABLE NO. 1.—PERCENTAGE COMPOSITION, ETHER EXTRACT, ACCORDING TO STELLWAAG.

	Total Fatty Acids.	Unsaponifiable.	Free Fatty Acids.	Lecithin.
Hay	60.1	30.8	37.3	+
Rye Bran	93.8	7.6	16.4	3.3
Wheat Bran	89.7	7.5	14.4	2.1
Barley Seed	86.7	6.1	14.0	4.3
Oat Seed	88.5	2.7	27.6	0.8
Corn Seed	91.5	3.7	6.7	2.9
Pea Seed	87.6	7.4	11.2	----------
Vetch Seed	80.8	7.4	14.8	27.4
Horse Bean Seed	79.9	5.9	9.8	22.9
Lupine Seed	89.6	6.8	8.1	21.3
Buckwheat Seed	85.7	7.2	12.5	4.5
Soja Bean Seed	94.0	1.5	1.9	1.9
Malt Germ	56.3	34.5	30.1	1.3
Rape Cake	87.3	3.3	13.5	3.6
Linseed Cake	94.3	1.9	8.9	7.0
Palm Cake	93.9	2.5	13.4	+
Cocoanut Cake	86.7	0.5	9.8	----------
Peanut Cake	94.2	1.5	86.9	----------
Sesame Cake	94.2	1.6	73.1	13.3
Sunflower Cake	90.4	1.8	29.8	----------
Cottonseed Cake	95.1	1.1	3.2	4.4
Potatoes	76.5	10.9	56.9	3.1
Beets	56.3	10.7	35.3	----------

LARGE SCALE METHOD FOR SEPARATING UNSAPONIFIABLE AND SAPONIFIABLE MATERIAL FROM ETHER EXTRACT.

Extraction of the Ether Extract: The dried substance, 25 to 33 grams, was placed in a large S. & S. paper fat capsule, in a Soxhlet apparatus with ground-in condenser and Sy flask with mercury seal. The ether used was always re-distilled, and was either ether pure by sodium, or U. S. P. ether, purified by washing with water and treatment with solid caustic soda. After four or five syphonings, the ether was removed and replaced by fresh ether; otherwise, the ether was liable to boil with explosive violence. The apparatus was sealed with calcium chloride tubes to protect from atmospheric moisture. After 16 hours extraction, a fresh charge of substance was put in and extracted. This was continued until 100 grams had been extracted. The extracts were combined, dried and weighed. Paper extraction capsules were used, because when excrement was being extracted, the fine particles passed through cotton, wool, or such other filter paper as we tried.

Separating Saponifiable and Unsaponifiable: The method is as follows:

Purification of Alcohol: Dissolve 1.5 grams silver nitrate in 3 cc water, add to 1000 cc alcohol and shake. Dissolve 3 grams caustic potash in about 25 cc warm alcohol and add to the alcohol. Shake, allow the precipitate to settle, pour off the alcohol and distil. Do not let stand longer than three days before pouring off.

Caustic Soda. Dissolve 40 grams caustic soda, pure by alcohol, in 500 cc purified alcohol, filter, and dilute to 1000 cc. Titrate 10 cc with N/5 hydrochloric acid. Ten cc should require 25 cc or more of the acid.

Saponification. Use 10 cc of the alcoholic soda for each 1 gram of the ether extract, and saponify by boiling in a 500 cc erlenmeyer flask with a reflux condenser, for at least an hour, shaking gently from time to time, and being very careful to see that the caustic comes in contact with all the fat which may be present in the flask. Add 0.5 gram sodium bicarbonate for every 10 cc of alcoholic soda used, and stir well. Evaporate off all alcohol in steam bath. Dry 30 minutes in a water oven.

Extraction of Unsaponified: Heat the soap prepared above with 100 cc petroleum ether, which distils below 80° C., for 20 minutes on reflux condenser, with shaking. Add 50 cc water and heat for 30 minutes longer. Draw off the clear petroleum ether by means of a separatory funnel, and filter through a paper previously extracted with ether. If it is not clear, wash, before filtering, with 50 cc 1 : 1 alcohol. Evaporate off the alcohol in a small dish, and return the material in the alcoholic wash to the original solution, using hot water. Make three extractions in all with petroleum ether as directed, collect, dry and weigh.

Heat the extracted soap with 100 cc ethyl ether as before, separate the clear ether, and wash three times with 30 cc water. Allow any emulsion to go back into the flask with the soap. Return the first washing

to the flask directly. Evaporate the others in a porcelain dish, and return before making the fourth extraction. Extract with ether in this way, four times. If any emulsion is then present, heat till the ether is all gone. Make a fifth extraction, and evaporate separately as a test of the completeness of the extraction. If the extraction is not sufficiently complete, continue it.

Extraction of Fatty Acids: Acidify with hydrochloric acid, remembering that you added a quantity of sodium bicarbonate. Extract the fatty acids with four extractions of ethyl ether, making a test on the fourth extraction.

Residue: Evaporate the extracted material and determine phosphoric acid therein. If any insoluble organic matter is present, and it contains no filter paper fibres, filter off the residue and wash with water, perforate the filter and wash into a weighed flask with alcohol, dry and weigh. If filter paper is present, extract the residue in the paper with successive portions of hot alcohol until colorless, combine, evaporate, dry and weigh. Determine phosphoric acid in the filtrate.

Addition: The following procedure was found of advantage in later stages of the work:

Put all extractions into 500 cc erlenmeyers, evaporate and transfer to weighed flasks with hot chloroform. It may be necessary to add alcohol to the petroleum ether extracts to facilitate the removal of the petroleum ether. The above procedure will prevent the loss of part of the products by retarded ebullition.

PURIFICATION OF THE PRODUCTS.

On account of the possibility of incomplete saponification, the products of the above process were put through a purification, described below. This purification was not altogether satisfactory. On the one hand, there was a loss of material due perhaps to solubility, and partly due to the production of insoluble substances during the purification. On the other hand, the change in the proportions of the saponifiable and the unsaponifiable was not as might be expected in various instances. The difficulty with the process lies in the solubility of the unsaponifiable matter in the soap solution so that it is very hard to extract. Then, also, there was danger of extraction of soaps in the ether, though the ether extract was always washed with water, per the method.

Purification of Unsaponifiable Material from Ether Extract (A): Combine the ether and petroleum soluble in a 500 cc flask and heat with alcoholic sodium hydroxide as in the saponification of fats. Add sodium bicarbonate. Evaporate off the alcohol, and heat residue with petroleum ether as in general method for separation. Add water as in general method and make two extractions with petroleum ether and four with ordinary ether as in general method. Make a test on the fourth ethyl ether extraction, and proceed further as seems advisable. Combine the extracted liquid with the fatty acid liquid as noted below.

Purification of Fatty Acids from Ether Extract (B): Heat the fatty acids with alcoholic sodium hydroxide, transfer to 500 cc erlenmeyer,

add sodium bicarbonate, evaporate, and extract twice with petroleum ether and five times with ethyl ether, proceeding as in the general method, and make a test of the fifth ether extraction. Combine the products with the purified unsaponified material.

To the extracted fatty acid liquid, add the extracted liquid from the unsaponified purification (A) above, which should also contain fatty acids. Acidify, and extract the fatty acids as in the general method.

TABLE NO. 2.—PERCENTAGE OF ETHER EXTRACT AND ITS CONSTITUENTS BY THE LARGE SCALE METHOD.

Laboratory Number.		Unsaponifiable.						Purification.		
		Total Ether Extract.	Petroleum Soluble.	Ethyl Ether.	Total.	Fatty Acids.	Insoluble.	Unsaponified.	Fatty Acids.	Insoluble.
3220	Cowpea Hay	3.15			1.69	1.33				
3222	Excrement Sheep No. 2	4.87	4.06	0.35	4.40	0.43				
3223	Excrement Sheep No. 3	5.03	3.98	0.50	4.48	0.46	0.12			
3224	Sorghum Hay	1.46	0.35	0.24	0.58	0.80		0.83	0.52	
3258	Excrement Sheep No. 1	1.93	1.00	0.37	1.36	0.53		1.52	0.39	
3259	Excrement Sheep No. 2	1.88	0.98	0.38	1.36	0.53		1.53	0.35	
3260	Excrement Sheep No. 3	1.87	0.86	0.58	1.44	0.44		1.56	0.34	
3277	Alfalfa Hay	1.28	0.35	0.38	0.73	0.49		0.71	0.43	
3279	Excrement Sheep No. 2	3.41	1.85	1.08	2.94	0.43		2.81	0.49	
3280	Excrement Sheep No. 3	3.49	1.85	1.11	2.95	0.56		2.84	0.51	0.05
3281	Excrement Sheep No. 4	3.46	1.91	1.12	3.03	0.39		2.88	0.44	0.08
3587	Johnson Grass Hay	1.29	0.44	0.33	0.77	0.49		0.64	0.50	
3589	Excrement Sheep No. 1	1.35	0.72	0.20	0.92	0.41		0.84	0.38	
3590	Excrement Sheep No. 3	1.53	0.80	0.20	1.00	0.48		1.01	0.46	
3591	Excrement Sheep No. 4	1.45	0.71	0.20	0.91	0.50		0.96	0.44	
3595	Oat Hay	2.41	0.32	0.43	0.74	1.55	0.01	0.54	1.59	
3597	Excrement Sheep No. 1	1.98	0.99	0.26	1.25	0.65		1.44	0.53	0.01
3598	Excrement Sheep No. 4	1.86	0.74	0.53	1.27	0.53		1.38	0.36	0.09
3669	Burr Clover	1.98	0.42	0.48	0.89	0.91	0.02	0.71	1.00	0.11
3623	Excrement Sheep No. 2	7.20	1.64	2.52	4.16	2.81		4.85	2.18	0.11
3624	Excrement Sheep No. 3	7.18	1.46	3.05	4.50	2.60		4.09	2.19	0.08
3625	Rice Straw	1.36	0.51	0.38	0.88	0.37	0.01	0.74	0.39	0.11
3877	Excrement Sheep No. 2	2.19	1.07	0.51	1.58	0.79		1.34	0.36	
3878	Excrement Sheep No. 3	2.07	0.98	0.48	1.46	0.32	0.31	0.95	0.48	0.20
3879	Excrement Sheep No. 4	2.26	1.48	0.39	1.87	0.27		1.55	0.34	0.14
3649	Vetch Hay	1.55	0.57	0.31	0.88	0.68		0.89		
3700	Excrement Sheep No. 1	2.17	1.15	0.30	1.45	0.71		1.71	0.34	
3883	Buffalo Grass Hay	1.25	0.65	0.15	0.80	0.44		0.55	0.55	0.07
3885	Excrement Sheep No. 2	1.52	1.14	0.19	1.34	0.14		0.99	0.40	0.05
3886	Excrement Sheep No. 3	1.40	0.79	0.11	0.89	0.49		1.61	0.19	
3887	Excrement Sheep No. 4	1.45	0.69	0.15	0.84	0.59		1.13	0.25	
4552	Guam Grass	1.78	0.52	0.71	1.23	0.51		0.81	0.62	0.20
4554	Excrement Sheep No. 1	1.57	1.17	0.19	1.36	0.30		1.09	0.34	0.07
4555	Excrement Sheep No. 3	1.40	0.96	0.17	1.13	0.25		1.05	0.15	0.15
4556	Excrement Sheep No. 5	1.51	1.07	0.18	1.25	0.25		1.14	0.18	0.14
4557	Corn Shucks	0.59	0.47	0.05	0.52	0.12		0.41	0.17	
4559	Excrement Sheep No. 1	0.84	0.66	0.07	0.73	0.14		0.71	0.14	
4560	Excrement Sheep No. 4	1.03	0.65	0.20	0.85	0.18		0.88	0.13	
4561	Excrement Sheep No. 5	1.21	0.87	0.17	1.03	0.20		1.08	0.14	

4663	Rice Straw	1.24	0.21	0.13	0.33	0.69	----------	0.08	0.56	0.41
4665	Excrement Sheep No. 1	1.48	0.63	0.13	0.76	0.37	0.36	0.83	0.22	----------
4666	Excrement Sheep No. 4	1.38	0.55	0.18	0.73	0.32	0.30	0.78	0.18	----------
4667	Excrement Sheep No. 5	1.66	0.83	0.20	1.03	0.30	0.34	0.86	0.17	----------
4238	Johnson Grass Hay	1.41	0.71	0.18	0.89	0.46	----------	0.58	0.65	----------
4240	Excrement Sheep No. 1	1.67	0.92	0.20	1.12	0.53	----------	1.29	0.38	----------
4241	Excrement Sheep No. 2	1.64	0.90	0.18	1.08	0.48	----------	1.16	0.30	----------
4242	Excrement Sheep No. 3	1.68	0.95	0.22	1.18	0.46	----------	1.32	0.28	----------
4247	Millet	1.53	0.46	0.17	0.64	0.35	----------	0.68	0.69	----------
4249	Excrement Sheep No. 1	1.70	1.03	0.36	1.39	0.33	----------	1.22	0.36	----------
4250	Excrement Sheep No. 3	1.63	0.75	0.54	1.29	0.17	----------	0.95	0.41	----------
4251	Excrement Sheep No. 4	1.46	0.52	0.32	0.84	0.55	----------	0.93	0.39	----------
4252	Bermuda Hay	1.52	0.75	0.53	1.28	0.28	----------	0.54	1.88	0.10
4254	Excrement Sheep No. 1	1.61	0.77	0.44	1.21	0.33	----------	1.22	0.20	----------
4255	Excrement Sheep No. 3	1.46	0.76	0.40	1.17	0.30	----------	1.12	0.24	0.07
4256	Excrement Sheep No. 4	1.53	0.97	0.36	1.34	0.19	----------	1.28	0.16	0.07
4259	Peanut Hay	8.89	0.27	----------	----------	8.33	----------	----------	----------	----------
4261	Excrement Sheep No. 1	2.65	1.05	0.70	1.75	0.90	----------	1.73	----------	0.15
4262	Excrement Sheep No. 3	2.73	1.22	0.54	1.77	1.01	----------	1.74	----------	0.07
4263	Excrement Sheep No. 4	2.63	1.31	0.95	2.25	0.33	0.05	1.27	1.07	0.10
4277	Para Grass	0.86	0.48	0.15	0.63	0.22	----------	0.58	0.24	----------
4279	Excrement Sheep No. 1	0.90	0.64	0.18	0.82	0.08	----------	0.58	0.29	----------
4280	Excrement Sheep No. 3	0.84	0.61	0.14	0.75	0.09	----------	0.57	0.21	----------
4281	Excrement Sheep No. 4	0.81	0.56	0.15	0.71	0.10	----------	0.59	0.16	----------
4546	Kafir Fodder	1.99	0.47	0.49	0.96	0.78	----------	0.75	0.84	----------
4548	Excrement Sheep No. 4	2.71	1.52	0.95	2.47	0.24	----------	2.11	0.52	----------
4594	Excrement Sheep No. 5	3.00	1.72	1.01	2.73	0.29	----------	2.46	0.46	----------
4550	Excrement Sheep No. 6	2.72	1.21	1.00	2.21	0.41	----------	2.09	0.49	----------

RESULTS OF THE LARGE SCALE METHOD.

Results with the large scale method are given in Table 2. This table shows the quantity of unsaponifiable extracted by the petroleum ether (3 extractions), the ethyl ether subsequent, and also the result of the purification. We are inclined to believe that the purification did not, in many cases, accomplish the purpose for which it was intended, and that the results of the first treatment are, in many cases, more nearly correct than the results of the purification.

The results also show the necessity for the extraction with ethyl ether following the petroleum ether. The ethyl ether always extracts an additional quantity of unsaponifiable, and in some instances, large quantities of it. For example, note the excrement from alfalfa hay, 3279 et seq., from Bermuda hay, 4254, and from kaffir fodder, 4548 et seq. The necessity for the extraction with ethyl ether is also shown by experiments on one set of the materials. A fourth petroleum extraction was made in this case, and evaporated separately. Then followed three successive extractions with ethyl ether, which were also evaporated separately. The results are shown in Table 3. The fifth extraction with ethyl ether is larger than the fourth with petroleum ether.

TABLE NO. 3.—ETHYL ETHER, SUCCEEDING PETROLEUM ETHER.

	Grams Unsaponifiable Extract.			
Laboratory numbers	3224	3258	3259	3260
Petroleum Ether, 4th Extraction	.0188	.0186	.0420	.0445
Ethyl Ether, 5th Extraction	.0440	.0537	.0622	.0920
Ethyl Eth_r, 7th Extraction	.0315	.0216	.0416	.0424
Ethyl Ether, 8th Extraction	.0276	.0138	.0260	.0185

TABLE NO. 4.—TESTS ON THE EXTRACTION OF UNSAPONIFIABLE—GRAMS UNSAPONIFIABLE DISSOLVED BY 100 cc. ETHER.

Laboratory Number	3587	3595	3597	3598	3609	3623	3624
Fifth Extraction	.0232	.0334	.0126	.0107	.0226		
Seventh Extraction	.0332	.0336	.0135				
Eighth Extraction							
Tenth Extraction	.0166	.0275	.0140	.0080	.0251		
Twelfth Extraction	.0202	.0153					
Thirteenth Extraction						.0851	.1346
Sixteenth Extraction					.0356	.0591	.0722
Twentieth Extraction					.0173		
Twenty-third Extraction						.0631	.0414

Insoluble material came out in certain of the extractions, notably with rice straw. In the purification, insoluble material is noted more often. With the exception of rice straw, the insoluble material (insoluble in water, petroleum ether and ethyl ether) was easily dissolved by alcohol. The insoluble from rice straw was not dissolved by any of the solvents tested, which included alcohol, ether, petroleum ether, chloroform, carbon tetracloride, ethyl acetate and glacial acetic acid. The insoluble substance was generally dark green in color and readily soluble in alcohol. It is possibly chlorophyll decomposition products, as it was greater in amount in those samples which were rich in chlorophyll (rice straw excepted).

The aqueous residues after extraction of saponified generally had a greenish tinge, and the color was more pronounced in samples rich in chlorophyll.

In a repetition of this experiment, products of burr clover and rice straw were dried in hydrogen to see if the insoluble would be lessened, but no difference was noted.

The residue from rice straw was straw-colored, elastic and spongy before drying. On drying it decreased greatly in bulk, darkened, and lost its elasticity and sponginess.

The difficulty in separating the unsaponifiable from the saponifiable is shown in the tests on some of the materials (see Table 4). We believe this is due to the solubility of the unsaponifiable in the aqueous soap solution. The weights in the tables also represent percentages in the materials, since 100 grams feed and excrement were used.

PROPERTIES OF THE SAPONIFIABLE MATERIAL.

The object of the large scale extraction was not only to ascertain the quantity of saponified and non-saponified matter, but also to determine the properties of each. The study of the saponified material has so far been confined to a determination of the saponification number, the melting point, and the iodine number. The saponified material always contained the green coloring matter extracted by the ether, the unsaponified being usually yellow in color. The methods used were as follows:

Method for Melting Point Determinations of Fatty Acids: Cover the bulb of a thermometer with a thin film of the fatty acid by dipping into the molten substance. Allow to stand 48 hours. Fix the instrument in a round bottom flask with the bulb in the center of the flask. Warm the flask slowly and read thermometer when the substance begins to assume the globular form. Heat all samples at a uniform rate. (Pohl-Carr Method; slightly modified as to standing 48 hours. See Wiley, Principles of Agricultural Analysis, III, page 322.)

Method for Determination of Saponification Number of Fatty Acids: Add ten cubic centimeters of alcoholic potash (40 gm. to 1000) free from carbonates, to each gram of fatty acids. Add alcohol if necessary and boil under reflux condenser for one hour. Stopper with cork to prevent access of air and titrate at once. Run a blank at the same time and the same way, using the same amount of added alcohol and ten cubic centimeters of alcoholic potash.

TABLE NO. 5—PROPERTIES OF THE SAPONIFIABLE.

Laboratory No.		Melting Point—Degrees.	Saponification Number.	Iodine Number.	Color.
3220	Cowpea Hay				
3222	Excrement Sheep No. 2				Brownish black.
3223	Excrement Sheep No. 3				
3224	Sorghum Hay		188		
3258	Excrement Sheep No. 1		162		Brown. No greenish tinge.
3259	Excrement Sheep No. 2		163		
3260	Excrement Sheep No. 3		164		
3277	Alfalfa Hay		237		
3279	Excrement Sheep No. 2		165		Greenish black.
3280	Excrement Sheep No. 3		176		
3281	Excrement Sheep No. 4		183		
3587	Johnson Grass Hay	71.05	156	28.8	
3589	Excrement Sheep No. 1	74.50	155	22.6	Dark brownish green.
3590	Excrement Sheep No. 3	75.50	149		
3591	Excrement Sheep No. 4	75.00			
3595	Oat Hay	35.00	217	46.6	
3597	Excrement Sheep No. 1	55.00	186	34.2	Greenish black.
3598	Excrement Sheep No. 4	63.00	166		
3609	Burr Clover	55.00	207	35.5	
3623	Excrement Sheep No. 2	85.00	167	42.8	Black green.
3824	Excrement Sheep No. 3	84.00	190		
3625	Rice Straw	100.00+	166	50.4	
3877	Excrement Sheep No. 2	100.00+	175		Brown.
3878	Excrement Sheep No. 3	100.00+	170	38.2	
3879	Excrement Sheep No. 4	100.00—			
3649	Vetch Hay	45.00	192	29.7	Dark brown.
3700	Excrement Sheep No. 1	63.00	180	36.4	
3883	Buffalo Grass Hay	58.00	168	28.7	
3885	Excrement Sheep No. 2	95.00		38.2	Black.
3886	Excrement Sheep No. 3	98.00	140		
3887	Excrement Sheep No. 4	94.00	136		
4238	Johnson Grass Hay	70.00	182	41.5	
4240	Excrement Sheep No. 1	73.00	140	33.3	Dark greenish brown or black.
4241	Excrement Sheep No. 2	71.00	148		
4242	Excrement Sheep No. 3	68.00	144		
4247	Millet	65.00	211	30.8	
4249	Excrement Sheep No. 1	67.00	173	33.9	Brown.
4250	Excrement Sheep No. 3	66.00	160		
4251	Excrement Sheep No. 4	67.00	157		
4252	Bermuda Hay	66.00	225		
4254	Excrement Sheep No. 1	95.00	174		Dark brown.
4255	Excrement Sheep No. 3	99.00	190		
4256	Excrement Sheep No. 4	90.00	195		
4259	Peanut Hay	Liq.	317	33.4	
4261	Excrement Sheep No. 1	56.00	205	18.2	Green brown
4262	Excrement Sheep No. 2	66.00	185		
4263	Excrement Sheep No. 4	66.00	189		
4277	Para Grass	72.00	195		
4279	Excrement Sheep No. 1	61.00	130		Brown.
4280	Excrement Sheep No. 3	60.00	136		
4281	Excrement Sheep No. 4	59.00	151		
4546	Kafir Fodder	68.00	185	30.3	
4548	Excrement Sheep No. 4	75.00	154	25.0	Yellow, dark brown.
4594	Excrement Sheep No. 5	74.00	161		
4550	Excrement Sheep No. 6	75.00	161		
4552	Guam Grass	71.00	224	29.9	
4554	Excrement Sheep No. 1		167	48.7	Black.
4555	Excrement Sheep No. 3	76.00	174		
4556	Excrement Sheep No. 5	71.00	178		
4557	Corn Shucks	59.00	213	36.2	
4559	Excrement Sheep No. 1	50.00	200	31.1	Brown.
4560	Excrement Sheep No. 4	59.00	177		
4561	Excrement Sheep No. 5	59.00	189		
4663	Rice Straw	64.00	167	44.0	
4665	Excrement Sheep No. 1	98.00+	169	49.7	Brown yellow.
4666	Excrement Sheep No. 4	98.00+			
4667	Excrement Sheep No. 5	98.00+	158		

The presence of the green coloring matter interfered seriously with the titration of certain of these samples, particularly excrement from burr clover.

Results: The results of the examination are presented in Table 5.

The saponification number of the feed is usually greater than that of the excrement. That is, the fatty acids of the lower molecular weight are more easily digested. For example, the average saponification number of 18 saponified products from feed is 203, while from the corresponding excrement it is 167. That is to say, the average fatty acid of the feed would correspond to daturic acid of the formula C_{17} H_{34} O_2 (or a mixture of equal proportions of palmitic and stearic acids), while that of the excrement would be erucic acid C_{22} H_{42} O_2. Thus the fatty acids of the lower molecular weight are more easily digested.

The melting points of the saponified products are also, as a rule, higher for the excrement than for the feed. The comparatively high melting point of the fatty acid corresponds to saturated acids of comparatively high molecular weight. The low iodine number also confirms this.

PROPERTIES OF THE UNSAPONIFIED.

The unsaponified matter was subjected to recrystalization from alcohol. Three products were secured:

(a) Very difficultly soluble in alcohol, easily soluble in chloroform.

(b) Soluble in hot alcohol and crystallizing out on cooling, as a bulky mass which shrinks greatly on drying. The mother liquors were combined, and recrystallized, leaving a second crop of crystals, more granular than the first.

(c) Easily soluble in alcohol, forming a semi-solid mass when the alcohol is evaporated.

The first products, those difficultly soluble in alcohol, were generally present only in small quantity, and were not further studied, except that an attempt was made to crystalize them from chloroform.

The second products, which separated from hot alcohol on cooling, were recrystallized a number of times from alcohol, usually until the melting point was not changed by the crystallization. In many cases, the quantity of the first product was so small that little could be done with it. However, several of the products were larger in quantity and were studied further.

The third product, soluble in alcohol, was undoubtedly a mixture.

All these materials will be subjected to further study.

The Crystalline Products: The product from burr clover, after four crystallizations (C_4) melted at 77-8°, and was converted into an acetyl compound, melting at 67.5°-68.5° C., with an acetyl value of 116.4. This would correspond to myricyl alcohol, C_{30} H_{62} O, the acetate of which has a value of 116.7. Analysis of the product gives the following results:

	Calculated for C_{30} H_{62} O	Found
H	14.20	14.01%
C	82.80	81.12%

When a portion of this substance was dissolved in chloroform and allowed to set some time, a granular crystalline substance separated out, which melted at 85°. Its acetyl compound melted at 71-72°.

The quantity of this product obtained from the other feeding-stuffs was not sufficient for a determination of the acetyl number, but estimations of carbon and hydrogen were made with the following results:

TABLE NO. 6—PERCENTAGE COMPOSITION OF CRYSTALLIZED PRODUCTS.

Laboratory No.	Origin.	Melting Point—Degrees.	Carbon.	Hydrogen.
----------	Sorghum Hay C_4	79	79.84	13.80
----------	Johnson Grass C_5	78-9	81.04	14.53
----------	Rice Straw C_4	81-2	75.15	12.69
4552	Guam Grass C_4	80-1	79.69	13.58
4663	Rice Straw C_4	84-5	75.89	13.29
4259	Peanut Hay	82-3	77.01	13.23

The recrystallized substances were also acetylated, recrystallized from alcohol, and the melting point of the acetyl product determined. In every case (save one, cowpea hay), the acetyl product melted at a lower temperature than the original compound. (See Table 7). The acetyl compound was also more granular when recrystallized from alcohol. We take this to be evidence of the formation of an acetyl compound, and that the crystallized compound consists of wax alcohols. Further, these wax alcohols approximate the composition of myricyl alcohol C_{30} H_{62} O for burr clover.

The second crop of crystals from the mother liquor were less pure than the first crop, and in some cases, larger in quantity. Analyses were made of two of these products, with the following results:

	Carbon per cent	Hydrogen per cent
3277 Alfalfa hay	80.47	12.40
4241 Millet	80.20	13.00

TABLE NO. 7—MELTING POINTS OF CRYSTALLIZED UNSAPONIFIABLE PRODUCTS AND OF THEIR ACETATES.

Laboratory No.	Origin.	Original Melting Point—Degrees.	Melting Point After Acetylation—Degrees.
3277	Alfalfa Hay C_4	80-2	68.0
3649	Vetch Hay C_4	78-9	68-9
3883	Buffalo Grass Hay C_4	80.5-1	71-2
4552	Guam Grass C_4	80-1	69-70
4557	Corn Shucks C_4	76-8	68-70
4663	Rice Straw C_4	84-5	71.3
4238	Johnson Grass Hay C_4	78-9	70-1
4247	Millet C_4	80.5-2	70-1
4252	Bermuda	79-80	69-70
4259	Peanut Hay	82-3	71-2
4277	Para Grass	79-80.5	69-70

The Product Easily Soluble in Alcohol: This was the mother liquor from the previous recrystallization, evaporated down. It was evidently not a single definite compound but evidently a mixture.

The saponification number of the acetyl compound of the product was determined in a number of cases with the following results:

TABLE NO. 8.

Origin.	Saponification Number of Acetyl Compound.
3224, Sorghum Hay	145.4
4552, Guam Grass	150.7
4557, Corn Shucks	144.0
4259, Peanut Hay	168.7
3625, Rice Straw	190.0
4238, Johnson Grass Hay	163.1
4252, Bermuda Hay	169.8
3595, Oat Hay	167.2
Octodecyl Alcohol, $C_{18}H_{37}OH$	180.0
Alcohol, $C_{20}H_{41}OH$	164.7
Alcohol, $C_{22}H_{43}OH$	153.0
Alcohol, $C_{23}H_{45}OH$	147.3
Alcohol, $C_{24}H_{47}OH$	142.1

The carbon and hydrogen in two of these mother liquors were:

	Carbon, Per Cent.	Hydrogen, Per Cent.
3220 Cowpea Hay	75.67	11.03
3609 Burr Clover	72.15	11.27
3625 Rice Straw	57.21	8.69

It is thus very probable that the unsaponifiable matter of these feeds consists largely of wax alcohols, and that these wax alcohols have a lower molecular weight than myricyl alcohol. The matter is being studied further.

If we assume these mother liquors to be composed entirely of wax alcohols, they would vary from $C_{18}H_{37}OH$ to $C_{24}H_{47}OH$. If, which is more probable, they consist of mixture of alcohols and other compounds, then wax alcohol must be present with a lower molecular weight than above stated.

Method of Determining Acetyl Number of Wax Alcohols: Boil about 2 grams (not necessary to weigh exactly) of the alcohol for about 2 hours under reflux condenser with about 4 cc acetic anhydride. Add about 100 cc water and heat on steam bath for an hour. Draw off the water and repeat until acid is washed out (Litmus paper test), making one more washing than is apparently necessary. Five washings are usually sufficient.

Dry and weigh the product, add 10 cc alcoholic potash (40 : 1000) for each gram of the acetylated product and boil under reflux condenser for 1 hour, running a blank on the potash solution at the same time. Titrate immediately with N/5 hydrochloric acid and phenolphthalein. Report the number of milligrams of potassium hydroxide neutralized per gram of the acetylated product.

METHOD FOR DETERMINATION OF SAPONIFIABLE AND UNSAPONIFIABLE MATTER.

Estimations of saponifiable and unsaponifiable in smaller amounts of the feeds were undertaken by the method described below. The object of this work was to secure a method which could be used for the estimation of saponifiable and unsaponifiable in the ether extract of feeds.

The methods for the purification of alcohol and preparation of caustic soda are the same as described under the large-scale method.

Extraction: Use 10 grams substance if it contains less than 3 per cent ether extract, and 5 grams if over 3 per cent. Extract for 16 hours, evaporate ether and dry to constant weight.

Saponification: Transfer to a 500 cc. Jena erlenmeyer with hot chloroform and evaporate off the solvent on water bath. Use 5 cc. of the alcoholic soda for each 1/2 gram of the ether extract, and 20 cc. alcohol. Saponify by boiling with a reflux condenser for 5 hours, shaking gently from time to time, and using great care that the caustic comes in contact with all the fat which may be present in the flask. Add 0.25 gram sodium bicarbonate for every 5 cc. of alcoholic soda used, and stir well. Evaporate off all alcohol in steam bath. Dry 30 minutes in a water oven.

Extraction of Unsaponified: Heat the soap prepared above with 50 cc. petroleum ether, which distils below 80° C., for 20 minutes on water bath under reflux condenser, with shaking. Add 25 cc. water and heat for 30 minutes longer. Draw off the clear petroleum ether and filter through a filter paper previously extracted with ether, if it contains any suspended matter. If the solution is not clear, wash with 25 cc. of 1 to 1 alcohol. By the use of a pear shaped separatory funnel and allowing the extract to stand, the insoluble matter will usually separate and fall to the bottom of the funnel, where it can be separated and returned to the original mixture. In case it is necessary to filter and use the alcohol wash, evaporate the alcohol washings in a porcelain dish after adding the products of extraction of the filter with alcohol and ether, and return to the soap solution by means of hot water and a steel spatula, before extracting the soap solution with ether. Extract twice with 50 cc. petroleum ether by heating 30 minutes as above. Place the combined extracts in a 500 cc. erlenmeyer and evaporate on water bath.

Heat the extracted soap with 50 cc. ethyl ether as before, separate the clear ether, and wash three times with 15 cc. water. Allow any emulsion to go back into the flask with the soap. Return the washings to the flask also. Extract with ether in this way four times. If any emulsion is then present, heat till the ether is all gone. Make a fifth extraction, and evaporate separately as a test of the completeness of the extraction. If this extraction weighs more than 1 per cent of the original ether extract, continue the extraction with ether until it is less than that amount. Put the ethyl ether extracts in the flask with the petroleum ether extracts and evaporate during the progress of the extraction. After completion of the ether extraction, evaporate off the rest of the petroleum ether and ethyl ether, adding alcohol to aid in the removal of the petroleum ether if necessary. Transfer to a tared 100 cc. erlenmeyer by means of hot chloroform. The small amount of sodium carbonate removed by the petroleum ether will remain in the large flask. Evaporate and dry to constant weight.

The following method of dealing with emulsions has proved satisfactory: Evaporate the emulsion in a separate flask until the ether is all gone, add 50 cc ether, and heat gently to redissolve unsaponifiable material. The ether extract can then be washed with water without the formation of an emulsion.

Extraction of Saponified Matter: Acidify with hydrochloric acid, testing with litmus paper. Extract with 50 cc. ethyl ether three times

by shaking the slightly warmed mixture in a separatory funnel and combine the extracts in a 500 cc. erlenmyer flask. Extract a fourth time as described in the removal of the unsaponified, wash with 2x15 cc water, dry and weigh separately. This extraction should weigh less than 1 per cent of the original ether extract. Wash the combined extracts with 2x50 cc. of water to remove sodium chloride. Return to erlenmeyer and evaporate to dryness, transfer to a tared 100 cc. erlenmyer with hot chloroform, evaporate and dry to constant weight.

Residue: If any insoluble organic matter is present, filter and wash with water. Perforate the filter and wash the residue into a tared vessel with alcohol, evaporate, dry and weigh.

Results: The results of a series of extractions by the method just described are given in the following table:

TABLE NO. 9—COMPOSITION OF ETHER EXTRACT—SMALL SCALE METHOD.

Laboratory No.		Total.	Unsaponified.	Saponified.	Insoluble.
3587	Johnson Grass Hay	1.24	.70	.50	
3589	Excrement Sheep No. 1	1.45	1.14	.28	
3595	Oat Hay	2.66	1.47	.78	
3597	Excrement Sheep No. 1	2.12	1.26	.60	.21
3609	Burr Clover	2.29	1.74	.52	
3623	Excrement Sheep No. 2	7.32	5.75	1.54	
3625	Rice Straw	1.47	.88	.34	.29
3877	Excrement Sheep No. 2	2.27	.81	.71	.55
3649	Vetch Hay	1.78	1.15	.52	
3700	Excrement Sheep No. 1	2.16	1.71	.40	
3883	Buffalo Grass Hay	1.28	.83	.33	
3885	Excrement Sheep No. 2	1.60	1.08	.38	
4663	Rice Straw	1.17	.74	.44	
4665	Excrement Sheep No. 1	1.27	.95	.32	
4252	Bermuda Hay	1.56	.98	.47	
4254	Excrement Sheep No. 1	1.59	1.36	.25	
4259	Peanut Hay	8.16	4.67	2.79	
4261	Excrement Sheep No. 1	2.61	1.56	.99	

On examination of the results, it was found that while many agreed well with the estimation in the large scale, yet with some feeds there were serious discrepancies. The unsaponifiable was in such case higher in the small method than in the large. It was thought possible that the larger proportion of petroleum ether and ethyl ether to the soap may have extracted some of the fatty acids. Accordingly, a further series of experiments was made, as described below.

CORRECTION OF FATTY ACIDS IN UNSAPONIFIABLE.

Proceed as described for the separation of the unsaponifiable. Then heat unsaponifiable for 15 minutes with 20 cc. of N/5 hydrochloric acid and 100 cc water. Let cool and pour off the water, through a filter if necessary. Heat to boiling with 50 cc. water, let cool and pour off again. The substance usually sticks to the flask, and the use of a filter is not necessary. Wash four times with water, dissolve in alcohol, and titrate with N/5 caustic soda and phenolphthalin. Calculate to palmitic acid.

Results: The results of a number of tests are given in Table 10.

TABLE NO. 10—COMPOSITION OF ETHER EXTRACT, CORRECTED FOR ACIDS IN UNSAPONIFIABLE.

Laboratory No.		Total Ether Extract.	Unsaponified.	Saponified.	Palmitic Acid in Unsaponified.
3595	Oat Hay	2.12	1.08	.98	.32
3669	Pure Clover Hay	2.72	1.99	.72	.35
3623	Excrement Sheep No. 2, D. E. VI	7.46	6.43	1.11	1.27
3624	Excrement Sheep No. 3, D. E. VI	7.60	6.50	1.15	1.50
3649	Vetch Hay	1.59	1.35	.31	.18
3878	Excrement Sheep No. 3, D. E. VII	1.85	.94	.71	.07
4259	Peanut Hay	8.17	5.23	2.28	1.42
4261	Excrement Sheep No. 1, D. E. XIII, Fed Peanut Hay	2.52			
4262	Excrement Sheep No. 3, D. E. XIII, Fed Peanut Hay	2.65	1.61	.86	.13
4263	Excrement Sheep No. 4, D. E. XIII, Fed Peanut Hay	2.66	2.22	.57	.25
4663	Honduras Rice Straw	1.17	.44	.51	.13
4665	Excrement Sheep No. 1, Fed Honduras Rice Straw, D. E. XVIII	1.42	.62	.62	.09
4247	Baled Millet	1.89	.98	.69	.29
3277	Alfalfa Hay	1.26	1.05	.28	.16
3279	Excrement Sheep No. 2, D. E. No. 3	3.56	5.19	.40	.39
4557	Corn Shucks	.61	.51	.07	.11
4559	Excrement Sheep No. 1, Fed Corn Shucks, D. E. XVII	.89	.88	.05	.09

The unsaponifiable material contains some fatty acids, in a few instances quite large amounts. On the other hand, it is possible that the soap may still contain some unsaponifiable, for the separation is a difficult one.

PETROLEUM AND ETHYL ETHER EXTRACTION.

The method calls for extraction first with petroleum ether, then with ethyl ether. This was adopted because, in the large method, the ethyl ether always dissolved considerable quantities of substance after the solution had apparently been extracted with petroleum ether. It was considered possible that the ethyl ether had a greater solvent action on the soap than the petroleum ether, and experiments were made to test this point. The petroleum ether extract and the ethyl ether extract were weighed and tested for fatty acids separately, with the results shown in Table 11.

TABLE NO. 11—SEPARATION OF ETHER EXTRACT BY PETROLEUM ETHER AND ETHYL ETHER.

Sample Number—	4238	4240	4546	4548
Total ether extract	1.36	1.74	2.27	2.63
Unsaponified—Petroleum Ether	.94	1.33	1.15	2.15
Acids in Above—Palmitic	.10	.03	.15	.10
Net Unsaponified—Petroleum Ether	.84	1.30	1.00	2.05
Unsaponified—Ethyl Ether	.24	.38	.64	.50
Acids in Above—Palmitic	.05	.07	.19	.08
Net Unsaponified Ethyl Ether	.19	.31	.45	.42
Total Unsaponified (net)	1.03	1.61	1.45	2.47
Saponified by Extraction	.20	.13	.47	.14
Total Saponified	.35	.23	.81	.32

Both solvents take up some of the soap. From one-third to one-fifth of the ethyl ether extract consists of fatty acids. The omission of the ethyl ether would not increase the accuracy of the method, and would leave a larger quantity of unsaponifiable matter with the fatty acids.

FINAL METHOD.

The method finally adopted consists of that described above, with a correction for the fatty acids in the unsaponifiable, as found by the test just referred to, assuming that the fatty acids are palmitic acid. The petroleum ether extract should also be washed with water to remove soaps which may have been extracted.

COMPOSITION OF THE ETHER EXTRACT OF HAYS AND FODDERS.

The composition of the ether extracts of the hays and fodders as calculated from the estimations most reliable is given in Table 12.

TABLE NO. 12—COMPOSITION OF ETHER EXTRACT OF HAYS AND FODDERS (PERCENTAGE).

Period Number.		Ether Extract Total	Unsaponifiable.	Saponifiable.	uble Residue. Insol-	Nitrogen.	phoric Acid. Phos-
3	Alfalfa Hay	1.26	67	33		.23	.06
12	Bermuda Hay	1.55	65	27		.38	.08
9	Buffalo Grass Hay	1.28	59	39		.33	.06
6	Burr Clover	2.72	60	39		.44	.10
17	Corn Shucks	.61	71	29		.20	.19
1	Cowpea Hay	3.15	54	42			.13
16	Guam Grass	1.78	69	29		.56	.14
4	Johnson Grass Hay	1.29	60	38		.26	.09
10	Johnson Grass Hay	1.38	75	25		.34	.15
15	Kafir Fodder	1.99	48	39		.39	.10
11	Millet	1.53	39	52		.19	.09
5	Oat Hay	2.12	36	61		.33	.05
14	Para Grass Hay	.86	73	26		.23	.25
13	Peanut Hay	8.17	47	45		.07	.18
7	Rice Straw, Japan	1.47	58	22	20	.26	.02
18	Rice Straw, Honduras	1.24	45	33	6	.18	.06
2	Sorghum Hay	1.47	56	35		.23	.09
8	Vetch Hay	1.59	70	30		.42	.06
	Average	1.91	58	36	.13	.30	.11

The unsaponifiable, consisting, as we have seen, largely of wax alcohols, varies from 36 to 73 per cent of the ether extract, with an average of 58 per cent. The saponifiable, which includes chlorophyll as well as fatty acids, varies from 23 to 61 per cent of the ether extract, with an average of 36 per cent. The percentage of nitrogen varies from .07 to .56 per cent, average 0.30, and the percentage of phosphoric acid from .02 to 0.18 per cent, average 0.11.

If we assume that the phosphoric acid present is in the form of lecithin, an assumption generally made, then the ether extract would contain 0.22 to 2.84 per cent lecithin, with average of 1.25 per cent, using the factor 11.38 to convert phosphoric acid to lecithin. Since lecithin contains 1.80 per cent nitrogen, the average amount lecithin-nitrogen in the ether extract would be .025 per cent, or one-twelfth of the nitrogen present.

The chlorophyll in the saponifiable is probably in the form of phyllotaonin $C_{40}\ H_{40}\ N_6\ O_6$, containing 12.0 per cent nitrogen.

We can assume that all the nitrogen present is either in lecithin or this chlorophyll product. The average for phyllantaonin-nitrogen

would then be 0.30—.025=0.275 per cent, equivalent to 2.3 per cent phyllotaonin in the total ether extract. This, however, is found in the saponifiable material of which it would constitute approximately 6.4 per cent. It is quite possible that other nitrogenous compounds are present, for rice straw ether extract, which contains little chlorophyll, contains almost as much nitrogen as the others.

The sum of the unsaponifiable and saponifiable is not 100 per cent. The loss may be due partly to formation of substances soluble in water during the saponification, such as glycerol, and partly to errors of analysis.

It is evident that the ether extract of hays, straws and fodders consists largely of substances which are not fats. The use of the term "fats" as synonomous with "ether extract" is, therefore, not justified, so far as these feeds are concerned.

TABLE NO. 13—PERCENTAGE COMPOSITION OF ETHER EXTRACT OF FEEDS AND EXCREMENT.

Laboratory No.		Unsaponified.	Saponified.	Insoluble.	Free, Fatty Acids (as Palmitic).	Nitrogen.	Phosphoric Acid.
3220	Cowpea Hay	54	42				.13
3222	Excrement, Sheep No. 2	90	90				.05
3223	Excrement, Sheep No. 3	89	9	2			.06
3224	Sorghum Hay	56	35		29	.23	.09
3258	Excrement, Sheep No. 1	79	20		10	.17	.06
3259	Excrement, Sheep No. 2	81	19				.05
3260	Excrement, Sheep No. 3	82	18				.04
3277	Alfalfa Hay	67	33		33	.23	.06
3279	Excrement, Sheep No. 2	82	14		14	.30	.03
3280	Excrement, Sheep No. 3	81	16	1			.03
3281	Excrement, Sheep No. 4	83	13	2			.04
3587	Johnson Grass Hay	60	38		26	.26	.09
3589	Excrement, Sheep No. 1	68	30		12	.17	.03
3590	Excrement, Sheep No. 3	65	31				.02
3591	Excrement, Sheep No. 4	66	34				.02
3595	Oat Hay	36	61		44	.33	.05
3597	Excrement, Sheep No. 1	63	33		11	.27	.03
3598	Excrement, Sheep No. 4	68	29				.02
3609	Burr Clover	60	39		27	.44	.10
3623	Excrement, Sheep No. 2	69	32			.56	.03
3624	Excrement, Sheep No. 3	66	35				.05
3625	Rice Straw	58	22	20	16	.26	.02
3877	Excrement, Sheep No. 2	34	30	23	7	.14	.01
3878	Excrement, Sheep No. 3	47	42				.02
3879	Excrement, Sheep No. 4	69	15	6			.03
3649	Vetch Hay	70	30		26	.42	.06
3700	Excrement, Sheep No. 1	79	19		10	.27	.06
3883	Buffalo Grass Hay	59	39		29	.33	.06
3885	Excrement, Sheep No. 2	74	26		14	.28	.03
3886	Excrement, Sheep No. 3	83	14				.03
3887	Excrement, Sheep No. 4	78	17				.03
4238	Johnson Grass Hay	75	25		25	.34	.15
4240	Excrement, Sheep No. 1	77	23		15	.26	.03
4241	Excrement, Sheep No. 3	71	18				.03
4242	Excrement, Sheep No. 4	79	17				.03
4247	Millet	39	52		22	.19	.09
4249	Excrement, Sheep No. 1	80	20		18	.17	.05
4250	Excrement, Sheep No. 3	79	19				.04
4251	Excrement, Sheep No. 4	66	28				.07
4252	Bermuda Hay	65	27		25	.38	.08
4254	Excrement, Sheep No. 1	85	15		11	.33	.01
4255	Excrement, Sheep No. 3	80	20				.01
4256	Excrement, Sheep No. 4	88	12				.01
4259	Peanut Hay	47	45		29	.07	.18
4261	Excrement, Sheep No. 1	60	38		26	.18	.10
4262	Excrement, Sheep No. 3	58	37				.08

TABLE NO. 13.—PERCENTAGE COMPOSITION OF ETHER EXTRACT OF FEEDS AND EXCREMENT—continued.

Laboratory No.		Unsaponified.	Saponified.	Insoluble.	Free, Fatty Acids (as Palmitic).	Nitrogen.	Phosphoric Acid.
4263	Excrement, Sheep No. 4--	70	30	----------	----------	----------	.12
4277	Para Grass ----------	73	26	----------	15	.23	.25
4279	Excrement, Sheep No. 1--	91	09	----------	9	.18	.08
4280	Excrement, Sheep No. 3--	89	11	----------	----------	----------	.07
4281	Excrement, Sheep No. 4--	88	12	----------	----------	----------	.07
4546	Kafir Fodder ----------	48	39	----------	27	.39	.10
4548	Excrement, Sheep No. 4--	91	09	----------	10	.38	.04
4594	Excrement, Sheep No. 5--	90	10	----------	----------	----------	.04
4550	Excrement, Sheep No. 6--	78	15	----------	----------	----------	.09
4552	Guam Grass ----------	69	29	----------	28	.56	.14
4554	Excrement, Sheep No. 1--	82	18	----------	10	.66	.06
4555	Excrement, Sheep No. 3--	81	10	----------	----------	----------	.06
4556	Excrement, Sheep No. 5--	83	17	----------	----------	----------	.04
4557	Corn Shucks ----------	71	29	----------	25	.20	.19
4559	Excrement, Sheep No. 1--	84	16	----------	----------	----------	.18
4560	Excrement, Sheep No. 4--	83	17	----------	----------	----------	----------
4561	Excrement, Sheep No. 5--	83	17	----------	13	.12	.08
4663	Rice Straw ----------	45	33	.06	19	.18	.06
4665	Excrement, Sheep No. 1--	56	15	.24	16	.11	.02
4666	Excrement, Sheep No. 4--	57	13	.22	----------	----------	.03
4667	Excrement, Sheep No. 5--	52	10	.20	----------	----------	.04

Table 13 shows the free fatty acids present, calculated as palmitic acid, and also the comparative composition of feed and excrement. It will be noted that a considerable proportion of the fatty acids are present in the free state. As already pointed out, this determination is subject to some error on account of the color of the solution.

The following is a summary of the average composition of ether extract of the feeds studied:

Unsaponifiable (largely wax alcohols)	58. %
Saponified	36. %
Phosphoric acid	0.11 %
Equivalent to lecithin	1.25 %
Total nitrogen	0.30 %
Nitrogen in lecithin	0.025%
Nitrogen remaining	0.275%
Equivalent to phyllotaonin in unsaponified	2.3 %

DIGESTIBILITY OF THE CONSTITUENTS.

The digestibility of the constituents of the ether extract was determined in 18 experiments on hays and fodders. In calculating the digestibility, the quantity of ether extract fed and excreted was taken from Bulletin 147, this Experiment Station, and the constituents thereof calculated from the percentage composition of the ether extract in the feed and in the excrement as shown in Table 13.

TABLE NO. 14—AVERAGE DIGESTIBILITY OF CONSTITUENTS OF ETHER EXTRACTS OF HAYS AND FODDERS.

Period Number.		Total Ether Extract.	Unsaponifiable.	Saponifiable.	Nitrogen.	Phosphoric Acid.
3	Alfalfa Hay	4.9	----------	59.1	----------	46.9
12	Bermuda Hay	46.9	31.2	69.0	57.9	93.5
9	Buffalo Grass Hay	35.5	14.3	68.9	48.7	67.8
6	Burr Clover	5.4	----------	8.6	----------	57.7
17	Corn Shucks	38.6	28.0	64.4	59.1	59.2
1	Cowpea Hay	28.6	10.9	84.7	----------	69.8
16	Guam Grass	57.2	49.1	73.9	49.0	83.8
4	Johnson Grass	52.2	47.0	60.1	65.8	87.5
10	Johnson Grass	49.3	48.9	61.0	62.7	90.1
15	Kafir Fodder	53.1	15.9	86.3	62.0	73.1
11	Millet	56.4	15.9	81.4	39.4	74.7
5	Oat Hay	68.9	43.4	84.2	74.8	83.7
14	Para Grass Hay	45.0	32.8	77.4	58.2	83.9
13	Peanut Hay	90.0	86.6	92.3	75.8	94.5
7	Rice Straw, Japan	.7	23.4	9.4	47.4	18.5
18	Rice Straw, Honduras	36.4	8.8	76.0	63.6	67.3
2	Sorghum Hay	53.5	32.9	74.7	64.5	73.8
8	Vetch Hay	42.4	34.8	63.7	63.0	42.1
	Average (18)	41.9	29.1	66.4	----------	70.4
	(17)	----------	----------	----------	52.5	----------

It was assumed that the insoluble belongs to the unsaponifiable. It may possibly consist of products of the decomposition of chlorophyll, and hence properly belongs with the saponifiable. The assumption does not affect the results greatly, except with rice straw. Whether or not the assumption is justified in the case of rice straw is a matter for further consideration.

The average digestibility of the constituents of the ether extract is given in Table 14. Table 15 contains the calculations on which Table 14 is based. The digestibility of the unsaponifiable varies from 0 to 86.6, with an average of 29.1. In every case except one (Japan rice straw), the unsaponifiable is digested to a less extent than the saponifiable, and in this one case we have added a large amount of insoluble to the saponifiable. The digestibility of the saponifiable varies from 8.6 to 92.3, with an average of 66.4. The unsaponifiable is digested less than the total ether extract, and the saponifiable much more.

The saponifiable fatty acids may be, in part, combined with wax alcohols, in the form of waxes. If so, this would account for a lower digestibility for the saponifiable fatty acids than for the fatty acids of concentrated feeding stuffs, which are present combined with glycerol, that is as fats and oils.

The digestibility of the nitrogen varies but is usually less than the unsaponifiable. On the average, it is 52.5. The phosphoric acid averages 70.4.

If we assume that the digestibility of the phosphoric acid represents the digestibility of lecithin, we find that lecithin is digested, on an average, more than the saponifiable. If we assume that the digestibility of the nitrogen represents that of chlorophyll product, then chlorophyll is digested less than the saponifiable and more than the unsaponifiable. Since the chlorophyll product is 2.3 per cent of the total ether extract, or 6.4 per cent of the saponifiable, deduction of chlorophyll from the saponifiable would raise the coefficient of digestibility for the remainder of the saponifiable. Hence the fatty acids in the saponifable are probably digested to a greater extent than the saponifiable itself.

We therefore conclude that the low digestibility of the ether extract of hays and fodders is due to the presence of wax alcohols, waxes, chlorophyll, and other substances not as easily digested as the fatty acids or fats and oils.

TABLE NO. 15—DIGESTIBILITY OF CONSTITUENTS OF ETHER EXTRACT OF HAYS AND FODDERS.

Digestion Period.	Laboratory No.		Total Ether Extract.	Unsaponifiable.	Saponifiable.	Nitrogen.	Phosphoric Acid.
1	3220	Cowpea Hay Eaten	120.8	65.2	50.7		.157
	3222	Sheep No. 2 Excreted	85.9	77.3	7.7		.043
		Sheep No. 2 Digested	34.9	7.9	43.0		.114
		Sheep No. 2 Digested, Percentage	28.88	12.1	84.8		72.6
1	3220	Cowpea Hay Eaten	120.8	65.2	50.7		.157
	3223	Sheep No. 3 Excreted	86.7	78.9	7.8		.052
		Sheep No. 3 Digested	34.1	6.3	42.9		.105
		Sheep No. 3 Digested, Percentage	28.23	9.7	84.6		66.9
2	3224	Sorghum Hay Eaten	79.7	44.6	27.9	.183	.072
	3258	Sheep No. 1 Excreted	38.5	30.4	7.7	.065	.023
		Sheep No. 1, Digested	41.2	14.2	20.2	.118	.049
		Sheep No. 1 Digested, Percentage	51.69	31.8	72.4	64.5	68.0
2	3224	Sorghum Hay Eaten	66.4	37.2	23.3		.060
	3259	Sheep No. 2 Excreted	31.2	25.3	5.9		.016
		Sheep No. 2 Digested	35.2	11.9	17.3		.044
		Sheep No. 2 Digested, Percentage	53.01	32.0	74.6		73.3
2	3224	Sorghum Hay Eaten	66.3	37.1	23.2		.060
	3260	Sheep No. 3 Excreted	29.4	24.1	5.3		.012
		Sheep No. 3 Digested	36.9	13.0	17.9		.048
		Sheep No. 3 Digested, Percentage	55.66	35.9	77.1		80.0
3	3277	Alfalfa Hay Eaten	62.0	41.5	20.5	.143	.037
	3279	Sheep No. 2 Excreted	60.3	49.4	8.4	.181	.018
		Sheep No. 2 Digested	1.7	—7.9	12.1	—.038	.019
		Sheep No. 2 Digested, Percentage	27.4	Negative	59.1	Negative	51.4
3	3277	Alfalfa Hay Eaten	62.0	41.5	20.5		.037
	3280	Sheep No. 3 Excreted	54.1	44.4	8.7		.016
		Sheep No. 3 Digested	7.9	—2.9	11.8		.021
		Sheep No. 3 Digested, Percentage	12.74	Negative	57.6		56.8
4	3277	Alfalfa Hay Eaten	61.4	41.1	20.3		.037
	3281	Sheep No. 4 Excreted	61.8	52.5	8.0		.025
		Sheep No. 4 Digested	—0.4	—11.4	12.3		.012
		Sheep No. 4 Digested, Percentage	Negative	Negative	60.6		32.4
4	3587	Johnson Grass Hay Eaten	59.5	35.7	22.6	.155	.054
	3589	Sheep No. 1 Excreted	31.0	21.1	9.3	.053	.009
		Sheep No. 1 Digested	28.5	14.6	13.3	.102	.045
		Sheep No. 1 Digested, Percentage	47.9	40.9	58.8	65.8	83.3
4	3587	Johnson Grass Hay Eaten	57.8	34.7	22.0		.052
	3590	Sheep No. 3 Excreted	26.1	17.0	8.1		.005
		Sheep No. 3 Digested	31.7	17.7	13.9		.047
		Sheep No. 3 Digested, Percentage	54.83	51.0	63.2		90.4
4	3587	Johnson Grass Hay Eaten	59.6	35.8	22.6		.054
	3591	Sheep No. 4 Excreted	27.5	18.2	9.4		.006
		Sheep No. 4 Digested	32.1	17.6	13.2		.048
		Sheep No. 4 Digested, Percentage	53.86	49.2	58.4		88.9
5	3595	Oat Hay Eaten	92.7	33.4	56.5	.306	.046
	3597	Sheep No. 1 Excreted	28.4	17.9	9.4	.077	.009
		Sheep No. 1 Digested	64.3	15.5	47.1	.229	.037
		Sheep No. 1 Digested, Percentage	69.36	46.4	83.4	74.8	80.4

TABLE NO. 15—DIGESTIBILITY OF CONSTITUENTS OF ETHER EXTRACT OF HAYS AND FODDERS—continued.

Digestion Period.	Laboratory No.		Total Ether Extract.	Unsaponifiable.	Saponifiable.	Nitrogen.	Phosphoric Acid.
5	3595	Oat Hay Eaten	91.6	33.0	55.9		.046
	3598	Sheep No. 4 Excreted	28.9	19.7	8.4		.006
		Sheep No. 4 Digested	62.7	13.3	47.5		.040
		Sheep No. 4 Digested, Percentage	68.45	40.3	85.0		87.0
6	3609	Burr Clover Eaten	84.7	50.8	33.0	.373	.085
	3623	Sheep No. 2 Excreted	89.2	61.5	28.5	.500	.027
		Sheep No. 2 Digested	—4.5	—10.7	4.5	—.127	.058
		Sheep No. 2 Digested, Percentage	Negative	Negative	13.7	Negative	68.2
6	3609	Burr Clover Eaten	84.5	50.07	33.0		.085
	3624	Sheep No. 3 Excreted	89.2	58.9	31.2		.045
		Sheep No. 3 Digested	—4.7	—8.2	1.8		.040
		Sheep No. 3 Digested, Percentage	Negative	Negative	5.5		47.1
7	3625	Rice Straw Eaten	44.0	34.3	9.7	.114	.009
	3877	Sheep No. 2 Excreted	43.1	24.6	12.9	.060	.004
		Sheep No. 2 Digested	0.9	9.7	—3.2	.054	.005
		Sheep No. 2 Digested, Percentage	2.05	28.3	Negative	47.4	55.6
7	3625	Rice Straw Eaten	42.2	32.9	9.3		.008
	3878	Sheep No. 3 Excreted	40.6	19.1	17.1		.008
		Sheep No. 3 Digested	1.6	13.8	—7.8		
		Sheep No. 3 Digested, Percentage	3.79	42.0	Negative		
7	3625	Rice Straw Eaten	42.7	33.3	9.4		.009
	3879	Sheep No. 4 Excreted	44.9	33.7	6.7		.013
		Sheep No. 4 Digested	—2.2	—0.4	2.7		—.004
		Sheep No. 4 Digested, Percentage	Negative	Negative	28.7		Negative
8	3649	Vetch Hay Eaten	63.2	44.2	19.0	.265	.038
	3700	Sheep No. 1 Excreted	36.4	28.8	6.9	.098	.022
		Sheep No. 1 Digested	26.8	15.4	12.1	.167	.016
		Sheep No. 1 Digested, Percentage	42.41	34.8	63.7	63.0	42.1
9	3883	Buffalo Grass Hay Eaten	48.0	28.3	18.7	.158	.029
	3885	Sheep No. 2 Excreted	28.8	21.3	7.5	.081	.009
		Sheep No. 2 Digested	19.2	7.0	11.2	.077	.020
		Sheep No. 2 Digested, Percentage	40.0	24.7	59.9	48.7	69.0
9	3883	Buffalo Grass Hay Eaten	47.9	28.3	18.7		.029
	3886	Sheep No. 3 Excreted	32.0	26.6	4.5		.010
		Sheep No. 3 Digested	15.9	1.7	14.2		.019
		Sheep No. 3 Digested, Percentage	33.19	6.0	75.9		65.5
9	3883	Buffalo Grass Hay Eaten	47.6	28.1	18.6		.029
	3887	Sheep No. 4 Excreted	31.7	24.7	5.4		.009
		Sheep No. 4 Digested	15.9	3.4	13.2		.020
		Sheep No. 4 Digested, Percentage	33.4	12.1	71.0		69.0
10	4238	Johnson Grass Hay Eaten	55.9	41.9	14.0	.190	.084
	4240	Sheep No. 1 Excreted	27.2	20.9	6.3	.071	.008
		Sheep No. 1 Digested	28.7	21.0	7.7	.119	.076
		Sheep No. 1 Digested, Percentage	51.35	50.1	55.0	62.7	90.5
10	4238	Johnson Grass Hay Eaten	55.9	41.9	14.0		.084
	4241	Sheep No. 3 Excreted	27.8	19.7	5.0		.008
		Sheep No. 3 Digested	28.1	22.2	9.0		.076
		Sheep No. 3 Digested, Percentage	50.27	53.0	64.3		90.5
10	4238	Johnson Grass Hay Eaten	55.9	41.9	14.0		.084
	4242	Sheep No. 4 Excreted	29.9	23.6	5.1		.009
		Sheep No. 4 Digested	26.0	18.3	8.9		.075
		Sheep No. 4 Digested, Percentage	46.51	43.7	63.6		89.3

TABLE NO. 15—DIGESTIBILITY OF CONSTITUENTS OF ETHER EXTRACT OF HAYS AND FODDERS—continued.

Digestion Period.	Laboratory No.		Total Ether Extract.	Unsaponifiable.	Saponifiable.	Nitrogen.	Phosphoric Acid.
11	4247	Millet Eaten	64.2	25.0	23.4	.122	.058
	4249	Sheep No. 1 Excreted	30.5	24.4	6.1	.052	.015
		Sheep No. 1 Digested	33.7	0.6	27.3	.070	.043
		Sheep No. 1 Digested, Percentage	52.49	2.8	81.7	57.4	74.2
11	4247	Millet Eaten	64.5	25.2	33.5	----------	.058
	4250	Sheep No. 3 Excreted	27.5	21.7	5.2	----------	.011
		Sheep No. 3 Digested	37.0	3.5	28.3	----------	.047
		Sheep No. 3 Digested, Percentage	57.36	13.9	84.5	----------	81.0
11	4247	Millet Eaten	64.3	25.1	33.4	----------	.058
	4251	Sheep No. 4 Excreted	26.2	17.3	7.3	----------	.018
		Sheep No. 4 Digested	38.1	7.8	26.1	----------	.040
		Sheep No. 4 Digested, Percentage	59.29	31.1	78.1	----------	69.0
12	4251	Bermuda Hay Eaten	63.8	41.5	17.2	.242	.051
	4254	Sheep No. 1 Excreted	30.9	26.3	4.6	.102	.003
		Sheep No. 1 Digested	32.9	15.2	12.6	.140	.048
		Sheep No. 1 Digested, Percentage	51.57	36.6	73.3	57.9	94.1
12	4252	Bermuda Hay Eaten	63.8	41.5	17.2	----------	.051
	4255	Sheep No. 3 Excreted	36.7	29.4	7.3	----------	.004
		Sheep No. 3 Digested	27.1	12.1	9.9	----------	.047
		Sheep No. 3 Digested, Percentage	42.48	29.2	57.6	----------	92.2
12	4252	Bermuda Hay Eaten	63.8	41.5	17.2	----------	.051
	4256	Sheep No. 4 Excreted	34.1	30.0	4.1	----------	.002
		Sheep No. 4 Digested	29.7	11.5	13.1	----------	.048
		Sheep No. 4 Digested, Percentage	46.55	27.7	76.2	----------	94.1
13	4559	Peanut Hay Eaten	342.4	160.9	154.1	.240	.616
	4561	Sheep No. 1 Excreted	32.4	1.94	12.3	.058	.032
		Sheep No. 1 Digested	310.0	141.5	141.8	.182	.584
		Sheep No. 1 Digested, Percentage	90.53	87.9	92.0	75.8	94.9
13	4559	Peanut Hay Eaten	342.4	160.9	154.1	----------	.616
	4562	Sheep No. 3 Excreted	34.3	19.9	12.7	----------	.027
		Sheep No. 3 Digested	308.1	141.0	141.4	----------	.589
		Sheep No. 3 Digested, Percentage	90.0	87.6	91.8	----------	95.6
13	4559	Peanut Hay Eaten	342.4	160.9	154.1	----------	.616
	4563	Sheep No. 4 Excreted	36.0	25.2	10.8	----------	.043
		Sheep No. 4 Digested	306.4	135.7	143.3	----------	.573
		Sheep No. 4 Digested, Percentage	89.49	84.3	93.0	----------	93.0
14	4277	Para Grass Eaten	34.3	25.0	8.9	.079	.086
	4279	Sheep No. 1 Excreted	18.6	16.9	1.7	.033	.015
		Sheep No. 1 Digested	15.7	8.1	7.2	.046	.071
		Sheep No. 1 Digested, Percentage	45.77	32.4	80.9	58.2	82.6
14	4277	Para Grass Eaten	36.0	26.3	9.4	----------	.090
	4280	Sheep No. 3 Excreted	20.0	17.8	2.2	----------	.014
		Sheep No. 3 Digested	16.0	8.5	7.2	----------	.076
		Sheep No. 3 Digested, Percentage	44.44	32.3	76.6	----------	84.4
14	4277	Para Grass Eaten	28.9	21.1	7.5	----------	.072
	4281	Sheep No. 4 Excreted	15.9	14.0	1.9	----------	.011
		Sheep No. 4 Digested	13.0	7.1	5.6	----------	.061
		Sheep No. 4 Digested, Percentage	45.0	33.6	74.7	----------	84.7
15	4546	Kafir Fodder Eaten	85.2	40.9	33.2	.332	.085
	4548	Sheep No. 4 Excreted	33.3	30.3	3.0	.126	.013
		Sheep No. 4 Digested	51.9	10.6	30.2	.206	.072
		Sheep No. 4 Digested, Percentage	60.92	25.9	91.0	62.0	84.7

TABLE NO. 15—DIGESTIBILITY OF CONSTITUENTS OF ETHER EXTRACT OF HAYS AND FODDERS—continued.

Digestion Period.	Laboratory No.		Total Ether Extract.	Unsaponifiable.	Saponifiable.	Nitrogen.	Phosphoric Acid.
15	4546	Kafir Fodder Eaten	85.2	40.9	33.2		.085
	4549	Sheep No. 5 Excreted	44.4	40.0	4.4		.018
		Sheep No. 5 Digested	40.8	0.9	28.8		.067
		Sheep No. 5 Digested, Percentage	47.89	2.2	86.8		78.8
15	4546	Kafir Fodder Eaten	87.7	42.1	34.2		.088
	4550	Sheep No. 6 Excreted	43.4	33.9	6.5		.039
		Sheep No. 6 Digested	44.3	8.2	27.7		.049
		Sheep No. 6 Digested, Percentage	*50.51	19.5	81.0		55.7
16	4552	Guam Grass Eaten	69.2	47.7	20.1	.388	.097
	4554	Sheep No. 1 Excreted	30.0	24.6	5.4	.198	.018
		Sheep No. 1 Digested	39.2	23.1	14.7	.190	.079
		Sheep No. 1 Digested, Percentage	56.65	48.4	73.1	49.0	81.4
16	4552	Guam Grass Eaten	69.2	47.7	20.1		.097
	4555	Sheep No. 3 Excreted	27.0	21.9	4.9		.016
		Sheep No. 3 Digested	42.2	25.8	15.2		.081
		Sheep No. 3 Digested, Percentage	60.98	54.1	75.6		83.5
16	4552	Guam Grass Eaten	69.2	47.7	20.1		.097
	4556	Sheep No. 5 Excreted	31.8	26.4	5.4		.013
		Sheep No. 5 Digested	37.4	21.3	14.7		.084
		Sheep No. 5 Digested, Percentage	54.05	44.7	73.1		86.6
17	4557	Corn Shucks Eaten	22.1	15.7	6.4		.042
	4559	Sheep No. 1 Excreted	12.4	10.4	2.0		.022
		Sheep No. 1 Digested	97.0	5.3	4.4		.020
		Sheep No. 1 Digested, Percentage	43.89	33.8	68.8		47.6
17	4557	Corn Shucks Eaten	21.9	15.5	6.4		
	4560	Sheep No. 4 Excreted	13.4	11.1	2.3		
		Sheep No. 4 Digested	8.5	4.4	4.1		
		Sheep No. 4 Digested, Percentage	38.82	28.4	64.1		
17	4557	Corn Shucks Eaten	21.8	15.5	6.3	.044	.041
	4561	Sheep No. 5 Excreted	14.6	12.1	2.5	.018	.012
		Sheep No. 5 Digested	7.2	3.4	3.8	.026	.029
		Sheep No. 5 Digested, Percentage	33.03	21.9	60.3	59.1	70.7
18	4663	Rice Straw Eaten	36.8	18.8	12.1	.066	.022
	4665	Sheep No. 1 Excreted	22.2	17.8	3.3	.024	.004
		Sheep No. 1 Digested	14.6	1.0	8.8	.042	.018
		Sheep No. 1 Digested, Percentage	39.67	5.3	72.7	63.6	81.8
18	4663	Rice Straw Eaten	37.3	19.0	12.3		.022
	4666	Sheep No. 4 Excreted	19.0	15.0	2.5		.006
		Sheep No. 4 Digested	18.3	4.0	9.8		.016
		Sheep No. 4 Digested, Percentage	49.05	21.1	79.7		72.7
18	4663	Rice Straw Eaten	32.3	16.5	10.7		.019
	4667	Sheep No. 5 Excreted	25.7	18.5	2.6		.010
		Sheep No. 5 Digested	6.6	—2.0	8.1		.009
		Sheep No. 5 Digested, Percentage	20.43	Negative	75.7		47.4

SUMMARY AND CONCLUSIONS.

(1) The ordinary method of shaking out the unsaponifiable from the soap solution with ether is not applicable to the ether extract of hays and fodders.

(2) Methods were devised for the separation of the saponifiable from the unsaponifiable.

(3) The saponified material contains fatty acids, chlorophyll products, and perhaps other substances.

(4) The average saponification number of 18 feed extracts is 203, and of the corresponding excrement extracts it is 167.

(5) The unsaponifiable material is composed largely of wax alcohols. A crystallized alcohol approximating myricyl alcohol was separated out, and alcohols of lower molecular weight are present in the mother liquor.

(6) The unsaponifiable matter of the hays and fodders extract varies from 36 to 72 per cent, with an average of 58 per cent.

(7) The average amount of lecithin would be 1.25 per cent, if all phosphoric acid is so present. The average amount of chlorophyll derivative, based on the nitrogen present after correction for lecithin, is 6.4 per cent of the saponifiable.

(8) The digestibility of the unsaponifiable varies from 0 to 86.6, with an average of 29.1. The digestibility of the saponifiable varies from 8.6 to 92.3, with an average of 66.4.

(9) The low digestibility of the ether extract of hays and fodders is due to the presence of wax alcohols, waxes, chlorophyll, and other substances not as easily digested as the free fatty acids, or fats.

(10) It is not correct to use the term "fats or oils" to designate the ether extract of hays and fodders.